

Modification and Re-test of HINS_SS1_SOL_03d

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Introduction

The prototype focusing solenoid for the HINS R&D linac SS1 section, HINS_SS1_SOL_03d, has been tested previously [1] and was found to have somewhat erratic quench behavior. This was assumed to have been caused by inadequate pre-load being applied during fabrication, which could allow some motion of the bucking coils and cause them to quench. Since the cold mass had not yet been welded into a helium vessel, a method to fix this problem was devised and implemented, and a re-test of the repaired cold mass was completed. The repair consisted of loosening the end flange bolts and, while stretching the beam tube, inserting a 0.014" brass shim at one (lead) end, then re-tightening the bolts as much as possible. A photo of the repaired solenoid is shown in Figure 1.

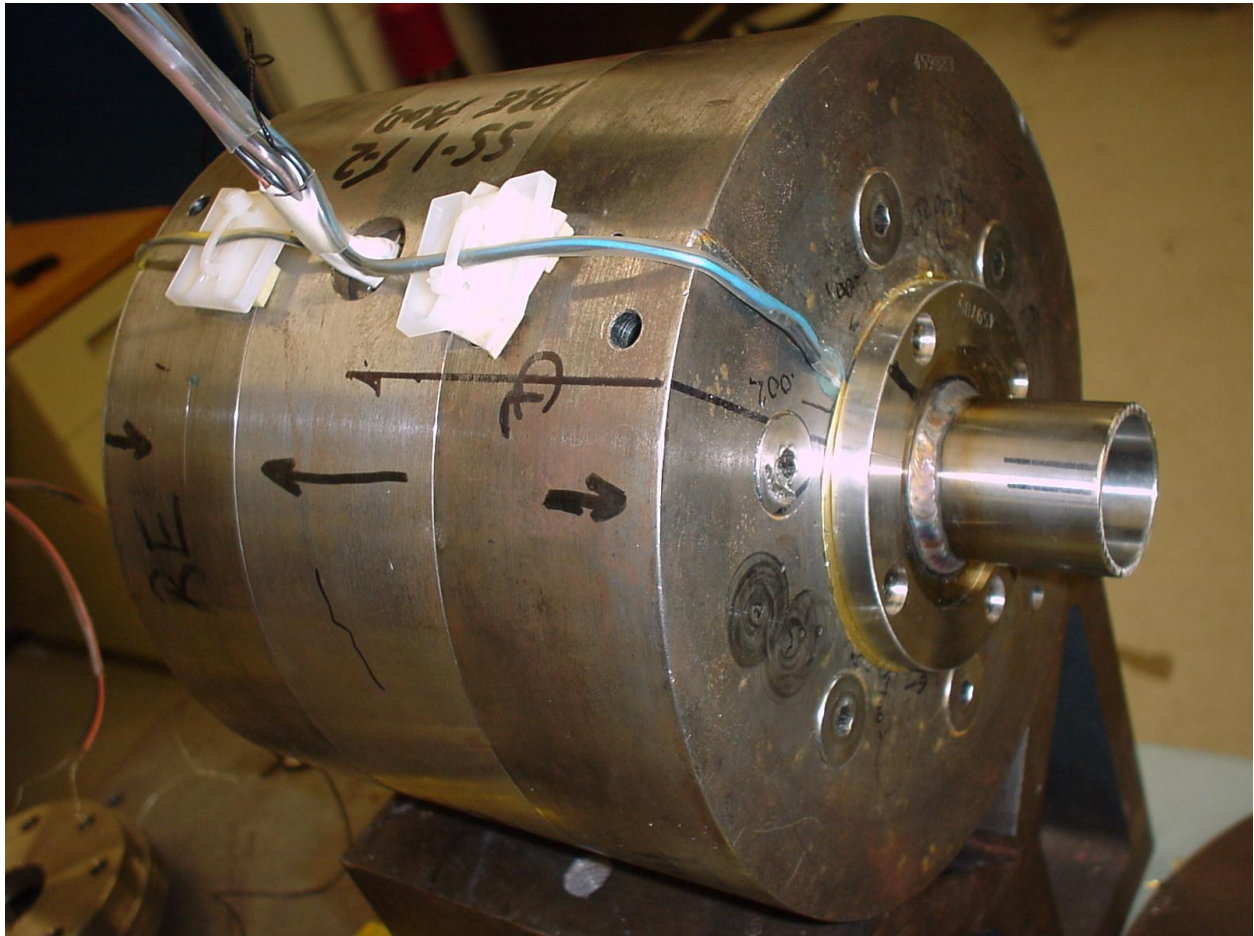


Fig. 1. Photo showing shim inserted between end flange and yoke at the solenoid lead end.

Test Overview

The solenoid was mounted on the MTF test stand 3 top plate assembly in the same orientation as the original test - with lead end (LE) up - and configured for separate powering of the solenoid, vertical dipole, and horizontal dipole. The magnet was cooled to 4.5 K on April 7, 2010, followed by a quench and power system checkout; a 0 A magnetic measurement was made to check the magnetization field, which showed that the Main and Bucking coils were properly wired to give the correct (opposite) field polarities. The cold test basically followed the same test plan as was conducted on the original device. Solenoid quench studies were made on April 9; a warm up to 190 K was made over weekend, and testing was performed on April 12 in a second thermal cycle. Quench training of the solenoid was completed and a magnetic measurement of the solenoid axial field profile was made at 180 A. To ensure no temperature-related quench problems, a minimum of 20 minutes between quenches was allowed to reach thermal equilibrium with the bath. Finally, quench performance of both dipole coils was checked in the solenoid field operating at 180 A.

Results

The solenoid quench performance clearly showed the expected improvement, as shown in Fig. 2. One training quench was seen the LE bucking coil, and subsequently all quenches were at the expected maximum current in the Main Coil (MC). No re-training was seen after the thermal cycle, and there were no other sporadic quenches at low current. Both dipole correctors reached their expected quench current (46 A) with no training, as is shown in Fig. 3.

Figure 4 shows the comparison – and very good agreement - of new data and model, and data from the original device, for the axial field transfer function profile around the solenoid center. In the first test [1] some difference between the measured and predicted fringe magnetic fields was seen. Therefore another scan of the axial field profile was made in this test specifically to determine if the profile changed after the shimming. Figure 5 shows these same data sets in the fringe field region: the agreement between new data and model is somewhat better, especially at large distance from the center where the field tends close to zero; the field at large distance for the original device is about 5.5 Gauss, and subtracting this offset it is seen that the shapes are clearly different. It is therefore reasonable to conclude that the bucking coil positions have changed with the increase in pre-load, and the resulting field is closer to the desired one.

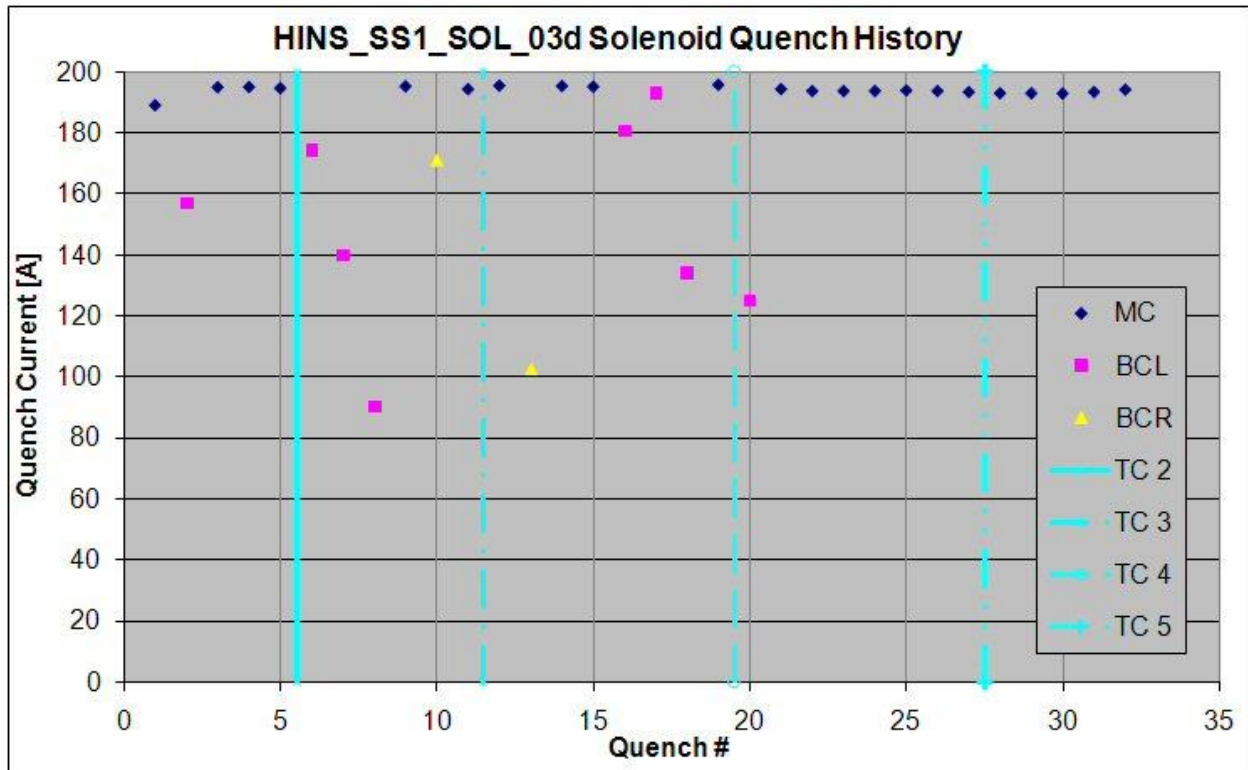


Fig. 2. Solenoid training history, showing improvement from the original device tested in three thermal cycles, to the shimmed device tested in two thermal cycles (4 and 5).

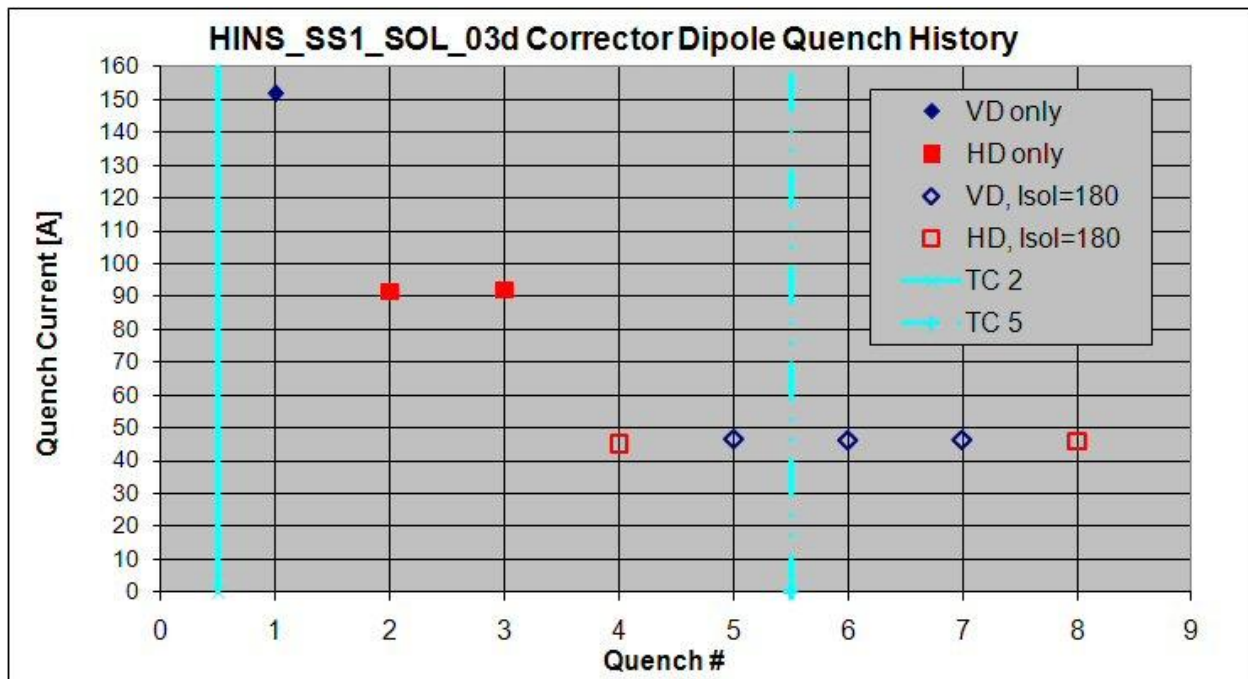


Fig. 3. Corrector dipole quench training history, for the original device tested in thermal cycle 2, and the shimmed device tested in TC 5.

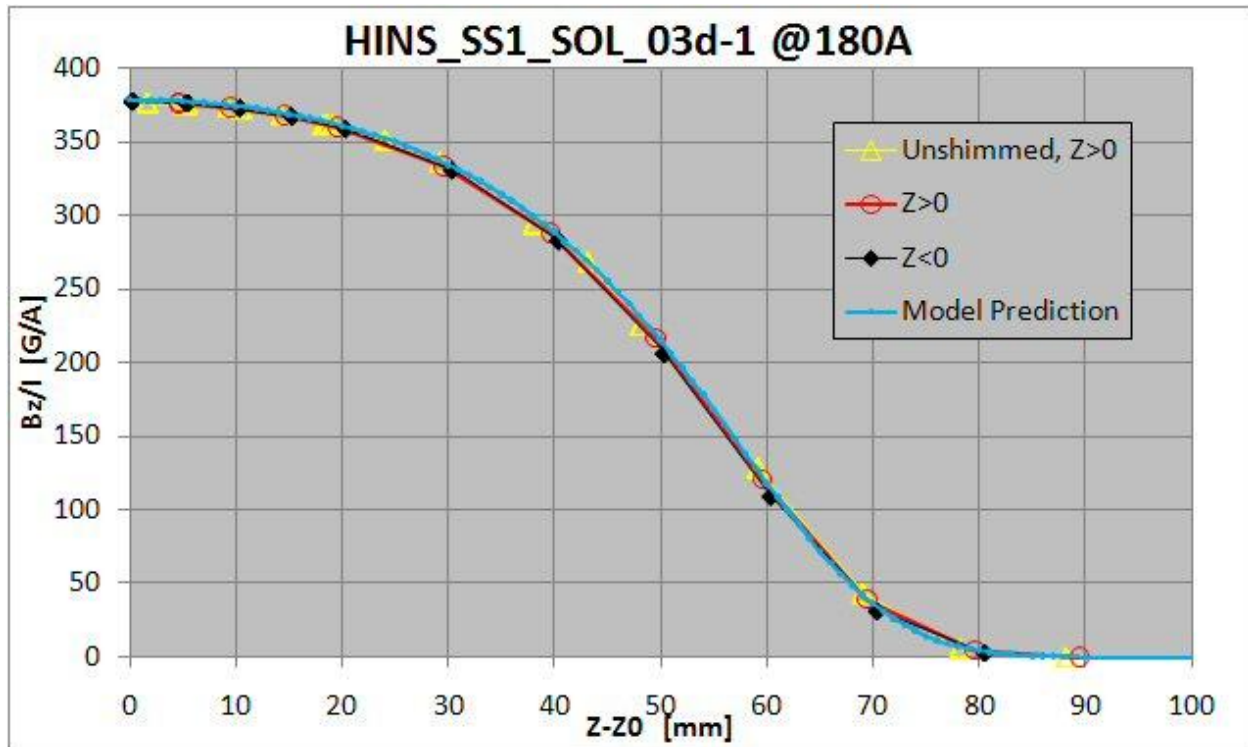


Fig. 4. Axial field transfer function profiles around the solenoid center for original device, shimmed solenoid, and model prediction at 180 A.

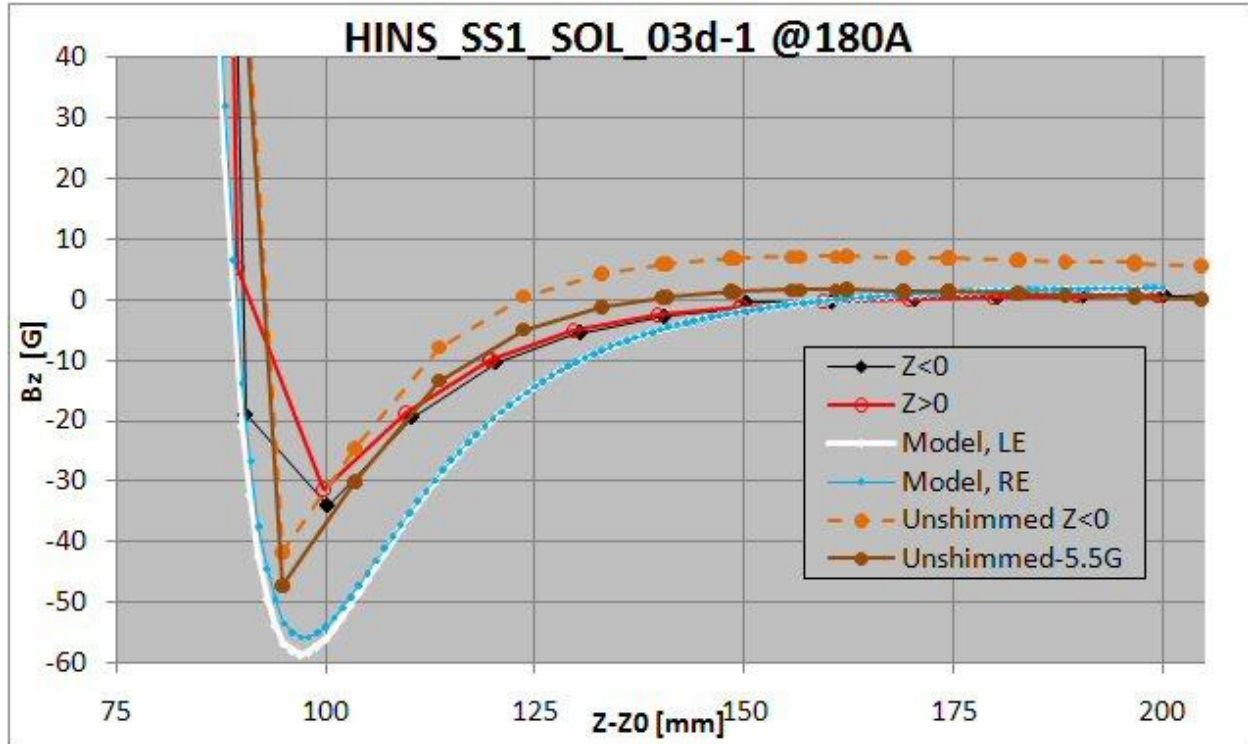


Fig. 5. Axial field profiles in the fringe field region for original device, shimmed solenoid, and model prediction at 180 A.

Conclusions

The pre-production type-2 SS1 focusing solenoid HINS_SS1_SOL_03d was modified after the first cold test showed somewhat erratic quench performance. This behavior was not unexpected, as a result of the end pre-load being less than desired during fabrication. A solution to increase the end pre-load was found and implemented, by adding a shim between the end flange and iron flux return. After making this repair the quench performance improved markedly, having only one training quench before reaching the expected quench plateau, and no re-training required after a thermal cycle. Slight changes in the fringe magnetic field are evident following addition of the shim, with the field reduced by about 5 Gauss at 200 mm from the solenoid center.

References

- 1] C. Hess, M. J. Kim, F. Lewis, D. Orris, M. Tartaglia, I. Terechkine, T. Wokas, "HINS_SS1_SOL_03d: Pre-Production SS1 Focusing Solenoid Fabrication and Test Results," FNAL TD note TD-10-002, February 2010